Spanish Journal of Agricultural Research (2004) 2(4), 504-511

Classification variables of cattle farms in the mountains of León, Spain

E. Serrano Martínez[1]*, P. Lavín González[1], F. J. Giráldez García[1], A. Bernués Jal[2] and A. Ruiz Mantecón[1]

[1] *Estación Agrícola Experimental del CSIC. Apdo 788. 24080 León. Spain*
[2] *SIA-Gobierno de Aragón. Apdo. 727. 50080 Zaragoza. Spain*

Abstract

This paper reports the first stage in the establishment of a farm classification system: the identification of classification variables. The aim of this work was to identify the variables most appropriate for characterising the cattle farms of the mountains of León, Spain, using multivariate and principal components analysis. The information used was obtained by surveying the cattle farms of the Montaña de Riaño (León) area from 1996-1998. The 35 variables taken into account in the principal components analysis refer to labour, the stock base, production, land use and farm economy. Seven principal components were found to explain 67.1% of the total variance.

Key words: stock raising systems, disadvantaged areas, principal components analysis.

Resumen

Identificación de variables de clasificación en explotaciones productoras de carne de vacuno en las montañas de León

En este trabajo se aborda la primera etapa de la realización de una tipología de explotaciones, que es la identificación de las variables de clasificación. El objetivo concreto de este trabajo fue identificar las variables más adecuadas para caracterizar y clasificar las explotaciones productoras de carne de vacuno de las montañas de León utilizando una técnica estadística multivariable, el análisis de componentes principales. La información utilizada fue obtenida mediante la realización de encuestas en explotaciones productoras de carne de vacuno de la comarca de Montaña de Riaño (León) y entre los años 1996 y 1998. Las 35 variables consideradas en el análisis de componentes principales se refieren a características de la mano de obra, base animal, producciones, utilización del territorio y economía de las explotaciones. A partir de dicho análisis se seleccionaron siete factores que explican el 67,1% de la varianza total.

Palabras clave: sistemas ganaderos, zonas desfavorecidas, análisis de componentes principales.

Introduction

The main aim of producing farm «typologies» is to identify groups of farms with common characteristics. This allows them to be compared, to make judgements on their performance, to look for solutions to problems, and to be able to make recommendations adapted to the reality of individual farms that might be extrapolated to others (Perrot and Landais, 1993; Chatellier *et al.*, 2000; Caballero, 2001).

The grouping of farms can be approached in several ways. However, when the aim is to group them in terms of production system (Manrique *et al.,* 1994), the technical and economic data that has to be handled includes many and often related variables. Multivariate analysis can be a useful tool for the *en masse* treatment of this kind of information (Bisquerra, 1989; Carrasco and Hernán, 1993; Rapey *et al.,* 2001).

Within the framework of segregative methods for producing typologies, both manual and multivariate (or automatic) statistical methods are available (Perrot and Landais, 1993). With respect to the latter, the classification criteria are not established *a priori* by the researcher and classification is generally not empirical. According to some authors, however, the use of such techniques is virtually limited to producing typologies based on structural and technical characteristics. Their usefulness in the production of typologies based on farm functioning and dynamics is very restricted,

* Corresponding author: e.serrano@eae.csic.es
Received: 10-04-03; Accepted: 14-07-04.

and some authors believe they could even lead to meaningless typologies or «objective typologies with no object» (Blanc and Allaire, 1979; Perrot and Landais, 1993; Gibon, 1994; Landais, 1998).

In the Spanish province of León, the mountainous areas are of relatively high importance. The majority of the area's mountains are concentrated in two areas: Montaña de Riaño and Montaña de Luna.

The population density fell from 1981 to 2001 in both these areas: from 12.0 to 8.4 km^{-2} in Montaña de Riaño, and from 19.5 to 15.8 km^{-2} in Montaña de Luna (Junta de Castilla y León, 1992, 2002b). At the same time, a number of environmental problems appeared (such as the proliferation of bushes, erosion, the loss of biodiversity and fires), frequently associated with changes in the use of the territory by agricultural and stock raising interests (Caraveli, 2000; MacDonald *et al.*, 2000). An example of the quantitative importance of these changes is the change in the percentage of land classified as being of agricultural use. In the Montaña de Riaño area this fell by 38.1% between 1982-1989 while the Montaña de Luna area lost 14.6%, and by 32.1% and 17.3% respectively from 1990-1999 (Lavín, 1996; Junta de Castilla y León, 2002a).

At the same time, both areas saw a very important increase in their cattle populations. Between 1989 and 2000 the number of head of cattle over six months old not destined for fattening increased by 49.8% in the Montaña de Riaño area and by 25.4% in the Montaña de Luna area. This was mainly due to the increase in the number of head for beef production: in the same period the number of beef cattle rose by 5481.8% and 3376.8% in these areas respectively. However, there was also a reduction in the number of cattle farms. Between 1989 and 2000, the number of cattle farms decreased by 48.0% in Montaña de Riaño, while the Montaña de Luna area experienced a 45.1% reduction. This of course implies a notable increase in the mean size of the remaining farms (188.9% and 128.7% respectively) (Junta de Castilla y León, 2002b).

The above changes are not exclusive to these areas; similar processes are underway in other disadvantaged areas of Spain and Europe. Stemming the depopulation and environmental deterioration of these areas requires the development and maintenance of sustainable stock raising systems. This, in turn, requires sufficient information be collected on the status of current stock raising systems plus the changes they undergo, as well as the availability of adequate analytical capacity (Caraveli, 2000; McDonald *et al*., 2000).

The present work (which forms part of a wider project) reports an attempt to establish a typology that allows the current situation of the cattle farms of the León mountains to be analysed. The process followed can be divided into two stages: the identification of the variables responsible for the differences between farms, and the establishment of homogeneous groups of farms according to these variables (Bisquerra, 1989; Carrasco and Hernán, 1993; Rapey *et al.,* 2001). The main objective of the present work lies within the first of these stages: the identification of the most appropriate variables for characterising and classifying these cattle farms using multivariate and principal components analysis (PCA).

Material and Methods

PCA is a descriptive, factorial, multivariate technique that eliminates redundancy when handling large numbers of variables that are frequently related (Bisquerra, 1989; Carrasco and Hernán, 1993). The process allows the substitution of a large table of quantitative data by one with a smaller number of variables (a linear combination of the originals) known as *principal components*. The number of principal components obtained can be equal to the number of variables included in the analysis, but from this total a reduced number is selected that explains an acceptable proportion of the overall variance. The number of principal components retained will depend on the phenomenon under study, on the precision required, and on their interpretability (according to the weight of each original variable within the principal component and the correlation between variables and principal components).

The information used in this work was obtained by directly surveying the farms of the Montaña de Riaño area in 1996, 1997 and 1998. The farms studied were all involved in a project, which began in 1996, to produce and market high quality beef from the León mountains. In the first year of the study, 75 farms were surveyed; the number of questionnaires considered adequately completed was 41. In the second and third years, 47 and 45 farms were surveyed; 35 valid sets of information were obtained for each. Thirty three farms were common to every year studied, two were common to the first and second year only, and two were common to the first and third year only.

The information gathered in these surveys, and treated by PCA, refers to production factors (labour,

the stock base, land use), the productive characteristics of the farms (types and quantities of produce), and economic aspects (costs, income and profit).

PCA analysis involved the use of the FACTOR and VARIMAX rotation procedures of the SAS statistical package (SAS, 1989). The information collected over the three years of the study was analysed together. Data pertaining to each farm and for each year of the study were taken as single observations, such that PCA was performed with a total of 111 observations (41 for 1996, 35 for 1997 and 35 for 1998).

Table 1 shows the starting set of variables – 85 in total. Correlation analysis was performed for these variables to eliminate those providing redundant information. This was undertaken using information gathered in 1998 since this data was considered the most representative of the farms' future prospects.

Table 1. Initial variables considered, related to the use of production factors, production characteristics and economic aspects of the farms

Labour
Breeding cows/AWU-cattle[b]

Land use
LU-total[c]/UAA[d]

Stock base
Breeding cows/farm (%)
Dairy cows (%)
Pardas (%)
Crossbreeds (%)
LU-other species (%)[e]
Mother cows (%)

Production
Litres milk sold/farm
Dif. litres milk sold-quota (%)[f]
Litres milk sold/breeding cow
% weaned grazing calves[g]
% finished calves[g]
% suckling calves[g]
% replacements[g]
% fattened calves[g]
Dead calves/ sold (%)
Dead calves/ calves born (%)
Calves sold/breeding cow
Calves born/breeding cow

Costs
Total costs[i]
Cattle costs[h]/breeding cow
Sanitary products
Feed
Feed bought
Pastures
Forage
Purchase of forage
Concentrates
Fuel
Electricity
Social security
Studs
Replacement cattle
Re-sold cattle
Maintenance
Insurance
Others
Sanitary products (%)
Feed (%)
Feed purchased (%)
Pastures (%)
Forage (%)
Concentrates (%)
Pastures / feed costs (%)
Forage / feed costs (%)
Concentrates / feed costs (%)
Feed purchased / feed costs (%)
Purchase of forage / forage costs (%)
Fuel (%)
Electricity (%)
Social security (%)
Studs (%)
Replacement animals (%)
Re-sold cattle (%)
Maintenance (%)
Insurance (%)
Others (%)

Income
Total income[k]
Income from cattle[j]/breeding cow
Calves
Adult cattle not for slaughter
Adults slaughtered
Milk
Subsidies
Capitalization calves
Capitalization adults
Calves (%)
Weaned grazing calves/income from calves
Suckling calves/income from calves (%)
Finished calves/income from calves(%)
Fattened calves/income from calves (%)
Replacements/income from calves (%)
Adult cattle not for slaughter (%)
Adults slaughtered (%)
Milk (%)
Subsidies (%)
Capitalization calves[n] (%)
Capitalization adults

Profits
GM-total[l]
I. subsidies/GM-cattle[m] (%)
GM-cattle/AWU-cattle
GM-cattle/breeding cow
GM-cattle without subsidies/breeding cow
GM-cattle without subsidies/AWU-cattle

[a]AWU: Annual work unit-work performed by one full time agricultural worker in one year. [b]AWU-cattle: Annual work units-referring specifically to the activity of cattle production. [c]LU-total: Livestock units belonging to the farm in question (number of cows, sheep, goats and mares, calculated according to the conversion indices described in the *Council Regulation (EEC) No. 1254/99,* 17 May 1999. [d]UAA: utilised agricultural area (ha-owned land/rented land upon which a farmer can depend over the years for agro-stock raising activities. Dairy cows (%), Pardas (%), crossbreeds (%), mother cows (%): % of dairy cows, Parda cattle, crossbreeds, and premium right suckling cows respectively. [e]LU-other species (%): % of the LU-total of a farm made up by sheep, goats and mares calculated according to the conversion indices described in the *Council Regulation (EEC) No. 1254/99,* 17 May 1999. [f]Dif. quota-litres milk sold (%): percentage derived from the difference between the number of litres of milk produced by a farm and the number of litres assigned by the quota, over the number of litres assigned by the quota. [g]% weaned grazing calves, % finished calves, % suckling calves, % replacements, % fattened calves: percentage of calves sold at weaning before fattening and fed only on milk and pasture; for slaughter; not fattened, 1-2 months old; replacements animals and those resold after their acquisition to another farm after a period of fattening. [h]Cattle costs: sum of costs of feed, sanitary products, fuel, electricity, maintenance of installations, cattle purchase, labour, insurance and others associated exclusively with cattle production. [i]Total costs: the sum of cattle costs plus those associated with other species (sheep, goats and/or horses). [j]Income from cattle: sum of the income from the sale of calves, adult cattle not for slaughter, adult cattle for slaughter, milk, subsidies and from the estimated variation in the number of animals held by the farm (capitalization of livestock). [k]Total income: sum of income from cattle and of other species or the sale of agricultural products. [l]GM-total: total gross margin- the difference between total income and total costs. [m]GM-cattle: gross margin for cattle-difference between income from cattle and cattle costs. [n]Income from calf capitalization: estimated variation in number of calves for one year. [o]I. capitalization adults: estimated variation in number of breeding cows and studs for one year.

Firstly, variables expressing the percentage costs and incomes of the farms were eliminated since these were strongly correlated to others expressed in terms of the number of breeding cows ($r \geq 0.50$ and $p < 0.005$ in all cases). The following were also eliminated: *litres milk sold/breeding cow* which correlated with *income from milk/breeding cow* ($r = 0.98$; $p < 0.001$); *mother cows (%),* which correlated with *income from subsidies/ breeding cow* ($r = 0.91$; $p < 0.001$); *% suckling calves,* which correlated with *% finished calves* ($r = –0.86$; $p < 0.001$); *dead calves/calves sold (%),* which correlated with *dead calves/calves born (%)* ($r = 0.90$; $p < 0.001$); *forage purchased/breeding cow,* which correlated with *forage costs/breeding cow* ($= 0.85$; $p < 0.001$); *feed costs/breeding cow* which correlated with *concentrates/breeding cow* ($r = 0.99$; $p < 0.001$); *feed costs/breeding cow,* which correlated with *concentrated costs/breeding cow* ($r = 0.96$; $p < 0.001$); *total costs,* which correlated with *total income* ($r = 0.91$; $p < 0.001$); *GM-total,* which correlated with *total income* ($r = 0.97$; $p < 0.001$); *GM-cattle without subsidies/breeding cow,* which correlated with *GM-cattle/breeding cow* ($r = 0.97$; $p < 0.001$) and *GM-cattle without subsidies/AWU-cattle,* which correlated with *GM-cattle/AWU-cattle* ($r = 0.94$; $p < 0.001$).

The initial set of variables was thus reduced to 41. Preliminary PCA was performed using this new set of variables to profile the structure of the principal components and to eliminate further variables that provided little information (low communality). The variables eliminated were: *pasture costs/breeding cow*, *stud service costs/breeding cow*, *insurance costs/breeding cow*, *other costs/breeding cow*, *dead calves/calves born (%)* and *income from cattle not for slaughter/ breeding cow*.

The final set of variables examined by PCA was 35 (Table 2).

Results

Table 3 shows the principle components selected by PCA, the variance explained by each, the variables with which there is an absolute variable-principal component correlation of > 0.5, and the degree of significance for each.

Seven axes explained 67.1% of the total variance. Figure 1 shows the variables used in PCA in the plane represented by the intersection of principal components (PC) 1 and 2.

Characterization of principal components

PC 1

PC 1 explains 18.9% of the total variance. Bearing in mind the most outstanding relationships between PC 1 and the variables considered, PC 1 can be defined as dealing with the «*orientation towards the production of milk, the intensification of the production system used, and the productivity per breeding cow*».

In terms of the significance of PC 1, its positive correlation with variables directly related to the

Table 2. Variables considered in principal components analysis

Labour
Breeding cows/AWU[a] cattle

Land use
LU-totals/UAA[c] LU[b] other species (%)

Production characteristics

Milk production
Litres milk sold/farm
Dif[d]. litres milk sold-quota (%)

Costs
Cattle costs/breeding cow
Sanitary products/breeding cow
Forage/breeding cow
Concentrates/breeding cow
Fuel/breeding cow
Electricity/breeding cow
Social security/breeding cow
Replacement cattle/breeding cow
Re-sold cattle/breeding cow
Maintenance/breeding cow

Profits
Income from subsidies/GM[e] cattle (%)
GM[e] cattle /breeding cow
GM[e] cattle /AWU[a] cattle

Stock base
Breeding cows/farm
Dairy cows (%)
Pardas (%)
Crossbreeds (%)

Calf production
% weaned grazing calves
% finished calves
% fattened calves
Calves sold/breeding cow
Calves born/breeding cow

Income
Total income
Income from cattle/breeding cow
Calves/breeding cow
Adults slaughtered/breeding cow
Milk produced /breeding cow
Subsidies/breeding cow
Capitalization of calves/breeding cow
Capitalization of adults/breeding cow

[a]AWU: Annual work units. [b]LU: Livestock units. [c]UAA: Utilised agricultural area. [d]Dif.: difference. [e]GM: gross margin.

Table 3. Factors selected from principal components analysis, the variance explained, the significance of each principal component, and correlation coefficients for each principal component and the variables that characterise them

	% variance explained (% accumulated variance explained) Eigen value	Significance of PC	Variables	Correlation with PC
PC 1	18.9	— Orientation	*Income from milk/breeding cow*	0.91
	(18.9)	— Milk production	*dairy cows (%)*	0.83
		— Intensification of	*litres milk sold/farm*	0.83
	6.6	production system	*Income from cattle/breeding cow*	0.82
		— Individual	*Pardas (%)*	0.71
		productivity per	*cost of concentrates/breeding cow*	0.68
		breeding cow	*GM-cattle/breeding cow*	0.66
			electricity costs/breeding cow	0.61
			Dif. litres milk sold-quota (%)	0.59
			Cattle costs/breeding cow	0.53
			crossbreeds (%)	–0.57
PC 2	12.2	— Productivity of	*GM-cattle/AWU-cattle*	0.87
	(31.1)	labour factor	*breeding cows/farm*	0.87
		— Farm size	*Total income*	0.86
	4.3		*breeding cows/AWU-cattle*	0.73
			social security costs/breeding cow	–0.55
PC 3	9.5	— General	*Cattle costs/breeding cow*	0.73
	(40.6)	management	*replacement costs/breeding cow*	0.71
			fuel costs/breeding cow	0.68
	3.3		*forage costs/breeding cow*	0.56
			maintenance costs/breeding cow	0.53
			costs sanitary products/breeding cow	0.52
PC 4	7.7	— Complementary	*Cost of re-sold cattle/breeding cow*	0.74
	(48.3)	activities	*% fattened calves*	0.73
			LU-other species (%)	0.70
	2.7		*income from capitalization of adults/breeding cow*	0.56
PC 5	6.9	— Efficiency of calf	*Calves sold/breeding cow*	0.91
	(55.2)	production	*income from calves/breeding cow*	0.87
			income from capitalization of calves/breeding cow	–0.57
	2.4			
PC 6	6.8	— Grazing system	*LU-total/UAA*	0.77
	(62.0)		*inc. adults slaughtered/breeding cow*	0.73
			% weaned grazing calves	0.50
	2.4		*calves born/breeding cow*	–0.61
PC 7	5.1	— Importance of	*% finished calves*	0.85
	(67.1)	calf finishing	*% weaned grazing calves*	–0.55
	1.8			

importance of milk production (*income from milk/breeding cow, dairy cows (%), litres milk sold/farm*) is its most outstanding feature. It also shows a strong, positive correlation with variables indicative of the degree of intensification of production (*cost of concentrates/breeding cow, cattle costs/breeding cow*), and with variables related to productivity per breeding cow (*GM-cattle/breeding cow, income from cattle/breeding cow*). Finally, PC 1 shows a strong correlation with the two variables relative to the breeds in the stock base, *Pardas (%)* and *crossbreeds (%)* (positive for the former, negative for the latter).

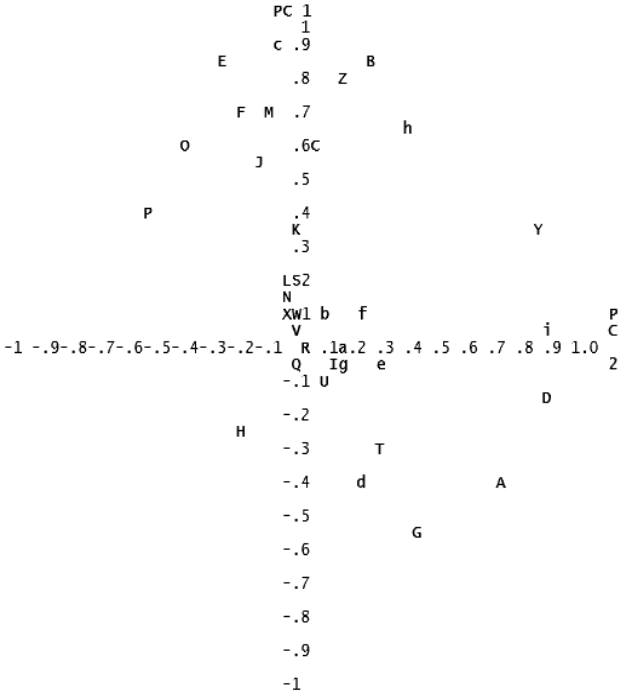

Figure 1. Representation of the variables considered in PCA in the factorial plane formed by the intersection of PC 1 and PC 2. A: Breeding cows/AWU-cattle; B: Litres milk sold/farm; C: Dif. quota-litres milk sold (%); D: breeding cows/farm; E: dairy cows (%); F: Pardas (%); G: crossbreeds (%); H: LU-other species (%); I: LU-total/UAA; J: cattle costs/breeding cow; K: g. sanitary products/breeding cow; L: forage costs/breeding cow; M: concentrates/breeding cow; N: g. fuel/breeding cow; O: g. electricity/breeding cow; P: social security costs/breeding cow; Q: costs replacement cattle/breeding cow; R: costs of re-sold cattle/breeding cow; S: g. maintenance/breeding cow; T: % weaned grazing calves; U: % finished calves; V: % fattened calves; W: calves sold/breeding cow; X: calves born/breeding cow; Y: Total income: Y; Z: income from cattle/breeding cow; a: income from calves/breeding cow; b: i. adults slaughtered/breeding cow; c: income milk/breeding cow; d: income subsidies/breeding cow; e: income from calf capitalization/breeding cow; f: i. From capitalization of adults/breeding cow; g: i. subsidies/GM-cattle (%); h: GM-cattle/breeding cow; i: GM-cattle/AWU-cattle.

In summary, PC 1 has high values in farms with *Parda* breed cows and an orientation towards milk production, with high production per breeding cow, and with relatively intense production systems.

PC 2

PC 2 explains 12.2% of the total variance. Given its relationship with the variables considered, PC 2 can be described as dealing with «*farm size and labour factor productivity*».

PC 2 was strongly and positively correlated with variables indicative of the size of the farm (*breeding cows/farm, total income*) and with those indicative of labour factor productivity (*GM-cattle/AWU-cattle, breeding cows/AWU-cattle*). In accordance, it was negatively correlated with *social security costs/ breeding cow*.

It therefore discriminates between farms according to their size (number of breeding cows), the labour requirements of the production system and labour factor productivity. PC 2 becomes important for farms with large numbers of cows, with production systems that allow the handling of many animals per worker, and with high labour factor productivity.

PC 3

PC 3 can be described as dealing with: «*aspects related to general farm management*». It explains 9.5% of the total variance and is strongly and positively correlated with: *cattle costs/breeding cow, costs of replacement animals/breeding cow*, *fuel costs/ breeding cow*, *forage costs/breeding cow, maintenance costs/ breeding cow* and *sanitary product costs/ breeding cow.*

PC 3 therefore characterises farms in terms of a number of different costs. The larger or smaller costs faced by farms differentiates them according to aspects of their functioning, e.g., whether a farm produces its own breeding animals and whether it is self-sufficient in forage. PC 3 acquires high values in farms with high costs for fuel, maintenance of installations, machinery, sanitary products, forage and animal replacement, and in farms where there is insufficient forage to cover needs or where replacement animals have to be bought.

PC 4

PC 4 explains 7.7% of the total variance. Taking into account its relationships with the variables studied, it can be defined as dealing with «*complementary activities*».

PC 4 is strongly and positively correlated with two variables indicative of farm development in terms of activities complementary to the production of milk and calves, such as the raising of sheep, goats or horses (*LU-other species (%)*) and the re-selling of cattle not for slaughter (*costs of re-sold cattle/breeding cow*). It is also strongly and positively correlated to *% fattened animals*.

PC 4 discriminates between farms in terms of whether they undertake activities complementary to milk and calf production, e.g., the fattening of weaned grazing calves bought from other farms, the raising of heifers and replacement cows, and the raising of other species.

PC 5

PC 5 explains 6.9% of the total variance and deals with the «*technical and economic efficiency of calf production*». PC 5 is strongly and positively correlated with two variables indicative of the efficiency of calf production: *calves sold/breeding cow* and *income from calves/breeding cow*. It is also strongly and negatively correlated with *income from calf capitalization/ breeding cow*. PC 5 therefore acquires high values in farms with many calves sold per breeding cow and with high income from this activity.

PC 6

PC 6 explains 6.8% of the total variance. Bearing in mind its relationship with the variables considered, this can be defined as dealing with «*extensive management based on grazing*». PC 6 is strongly and positively correlated with the stocking rate per hectare of UAA (*LU-total/UAA*), with income from sales of adult cows for slaughter per breeding cow (*income adults slaughtered/breeding cow*) and from the percentage of calves sold as weaned grazing calves *(% weaned grazing calves*). In addition, PC 6 is strongly and negatively related to *calves born/breeding cow*.

Taking into account its correlation coefficient with *LU-total/UAA*, PC 6 takes high values in farms with high stocking rates per unit of UAA. This characteristic is associated with reduced availability of UAA and being able to use large areas of common grazing ground.

According to the most outstanding relationships between PC 6 and the variables within this factor, the above characteristics are related to others such as a high breeding cow replacement rate, low reproductive success, and a high percentage of calves sold as weaned grazing calves.

PC 7

PC 7 explains 5.1% of the total variance. Given its relationship with the variables included in the PCA analysis, this factor can be defined as dealing with «*calf finishing*». PC 7 was strongly and positively associated with the percentage of calves sold for slaughter *(% finished calves*), and strongly but negatively associated with the percentage of calves sold as weaned grazing calves *(% weaned grazing calves*). PC7 therefore discriminates between farms in terms of the percentage of calves that complete the production process, increasing their income in line with the relative importance of the number of calves sold for slaughter.

Discussion

The results show that the farms studied can be characterised in terms of two types of variable: those forming what might be termed *basic explanatory factors* of the variations between farms, and *secondary* factors (which complement and complete the former).

The basic explanatory factors are represented by PC 1 and 2, and are defined by variables indicative of the orientation of production, the intensification of the production system and the productivity per breeding cow, the productivity of the labour factor, and farm size.

The above characterisation of farms can be qualified in terms of the characteristics that define the rest of the principal components selected (general management, complementary activities, calf production efficiency, and characteristics associated with the grazing system and the importance of calf fattening).

PC 1 and 2 are defined by variables that might be understood as more general (necessary in any attempt to characterise and classify farms) and as defining the production system (orientation, size etc.) (Milan, 1997; Chatellier *et al*., 2000; Caballero, 2001). The secondary factors are, however, defined by more specific variables of the study area and with respect to the exact aims of the research etc.

The PCs selected show a strong degree of similarity with those obtained by other authors who have attempted to classify cattle farms in similar areas. For example, they are very similar to those reported by Olaizola *et al.* (1995), who used PCA to examine 11 variables concerned with the technical and economic characteristics of 50 cattle farms in the Pyrénées. As a result of using PCA to examine 15 variables concerning the same characteristics of 30 cattle farms in the Haute Loire mountains (France), Dobremez *et al.* (1990) obtained two main axes that explained the variation between these farms. The first referred to

specialisation in milk production, the degree of intensification and the individual productivity per breeding cow; the second distinguished farms basically in terms of their degree of modernization.

Though it is difficult to establish similarities with other studies — basically because the starting variables are different— the characteristics that defined the secondary factors in the present work are also reported to be of importance by other authors. For example, Rodríguez and Alfageme (1996) characterised the cattle farms of the Principality of Asturias (northern Spain) in terms of two principal components defined by the relative importance of grazing in the feed of cows and calves, by the conservation of forage, and by the characteristics of the calves at sale (either fattened or at weaned).

Together, the results show the usefulness of PCA in characterising farms. This type of analysis allows one to select from a large number of variables those of greatest importance in explaining the differences between farms. It should be remembered, however, that in the use of this technique, one must evaluate the practicality and potential of any classification derived from the principal components/variables selected. This requires researchers have a certain empirical knowledge of the realities of such farms.

Acknowledgements

This work forms part of the project CYCYT-FEDER 1FD1997-0776 and of a research contract between the Spanish Council for Scientific Research (CSIC) and the company *Núcleo de Explotaciones Agropecuarias de León, NEAL, S. A*.

References

BISQUERRA R., 1989. Introducción conceptual al análisis multivariable. Promociones y Publicaciones Universitarias, Barcelona. 410 pp.

BLANC M., ALLAIRE G., 1979. Types d'exploitations et des couchés sociales dans l'agriculture. Revue Géographique des Pyrénées et du Sud Ouest 50, 343-369.

CABALLERO R., 2001. Typology of cereal-sheep farming systems in Castile-La Mancha (south-central Spain). Agr Syst 68, 215-232.

CARAVELI H., 2000. A comparative analysis on intensification and extensification in mediterranean agriculture: dilemmas for LFAs policy. Journal of Rural Studies 16, 231-242.

CARRASCO J.L., HERNÁN M.A., 1993. Estadística multivariante en las ciencias de la vida. Ediciones Ciencia 3, Madrid. 625 pp.

CHATELLIER V., COLSON F., FUENTES M., VARD T., 2000. Les exploitations d'élevage herbivore dans l'Union Européenne. INRA Production Animal 13, 201-213.

DOBREMEZ L., LIENARD G., BARRET M., 1990. Systèmes de production laitière en montagne: Evolutions récentes et adaptations possibles. Exemple d'exploitation en Haute-Loire. INRA Production Animal 3, 329-345.

GIBON A., 1994. Dispositifs pour l'étude des systèmes d'élevage en ferme. In: The study of livestock farming systems in a research and development framework (Gibon A., Flamant J. C., eds.). Wageningen Pers, Holland. pp. 410-422.

JCyL, 1992. Anuario Estadístico de Castilla y Léon, 1991. Junta de Castilla y Léon, Valladolid, Spain. 512 pp.

JCyL, 2002a. Anuario Estadístico de Castilla y Léon, 2001. Junta de Castilla y Léon, Valladolid, Spain. 565 pp.

JCyL, 2002b. Servicio Territorial de Estadística y Estructuras Agrarias de la Junta de Castilla y León. Internal use document.

LANDAIS E., 1998. Modelling farm diversity. New approaches to typology building in France. Agr Syst 58, 505-527.

LAVÍN M.P., 1996. Los sistemas de producción ovina de la provincia de León: factores condicionantes de su distribución y estructura. Doctoral thesis. University of León, Spain.

MACDONALD D., CRABTREE J.R., WIESINGER G., DAX T., STAMOU N., FLEURY P., GUTIERREZ LAZPITA J., GIBON A., 2000. Agricultural abandonment in mountain areas of Europe: environmental consequences and policy response. J Environ Manage 59, 47-69.

MANRIQUE E., MAZA M.T., OLAIZOLA A., 1994. Classification systems in livestock farming: how and why? The point of view of a production economist. In: The study of livestock farming systems in a research and framework (Gibon A., Flamant J.C., eds.). Wageningen Pers, Holland. pp. 213-217.

OLAIZOLA A.M., MANRIQUE E., MAZA M.T., 1995. Tipos de sistemas de producción y rendimientos económicos en las explotaciones de vacuno de montaña. ITEA Prod Anim 91A, 47-58.

PERROT C., LANDAIS E., 1993. Exploitations agricoles: pourquoi poursuivre la recherche sur les méthodes typologiques? Cahiers de la Recherche et Développement 33, 13-23.

RAPEY H., LIFRAN R., VALADIER A., 2001. Identifiying social, economic and technical determinants of silvopastoral practices in temperate uplands: results of a survey in the Massif Central region of France. Agr Syst 69, 119-135.

RODRÍGUEZ A.A., ALFAGEME L.A., 1996. Características técnico-económicas de los sistemas productivos de carne vacuna del Principado de Asturias. ITEA Prod Anim 92A, 77-91.

SAS, 1989. SAS/STAT® User's Guide Int. Vers 6, 4th ed. Statistical Analysis Systems Institute Inc., Cary, NC, USA. 1674 pp.